TECHNOLOGY NEEDS/OPPORTUNITIES STATEMENT

TECHNIQUES TO DELINEATE GROUNDWATER PLUMES IN THREE DIMENSIONS AND DEFINE A SCIENTIFIC BASIS FOR ADDRESSING SCALING ISSUES IN HANFORD GROUNDWATER

Identification No.: RL-SS33
Date: September 2001

Program: Environmental Restoration
OPS Office/Site: Richland Operations Office/Hanford Site
Operable Unit(s): Broad need potentially applicable to multiple operable units.
PBS No.: RL-SS04 (RL-VZ01)
Waste Stream: Groundwater (Disposition Map Designation: ER-10 [technical risk score 5] and ER-18 [technical risk score 5])
TSD Title: N/A
Waste Management Unit (if applicable): N/A
Facility: N/A

***Priority Rating*:**

This entry addresses the "Accelerated Cleanup: Paths to Closure (ACPC)" priority:

X 1. Critical to the success of the ACPC
____ 2. Provides substantial benefit to ACPC projects (e.g., moderate to high lifecycle cost savings or risk reduction, increased likelihood of compliance, increased assurance to avoid schedule delays)
____ 3. Provides opportunities for significant, but lower cost savings or risk reduction, and may reduce uncertainty in ACPC project success.

***Need Title*:** Techniques to Delineate Groundwater Plumes in Three Dimensions and Define a Scientific Basis for Addressing Scaling Issues in Hanford Groundwater

Need/Opportunity Category: Technology Need

***Need Description*:** This need addresses specific technical gaps identified in the scope of the Groundwater/Vadose Zone Integration Project (Integration Project) at the Hanford Site and is written as an "integrated" need. The Integration Project is focused on providing the scientific and technical basis to ensure that Hanford Site decisions, including decisions related to long-term stewardship, are defensible and possess an integrated perspective for the protection of water resources, the Columbia River, river-dependent life, and users of the Columbia River resources. As such, this "integrated" need has both applied S&T components that are interrelated in addressing the specified technical gap. Individual efforts applied to resolve the technical gaps described in this need may address all or part of the components identified for this need. Where a specific technology need can be defined separately from an "integrated" need, a specific technology need statement has been written and is included elsewhere in the Hanford Site STCG

Subsurface Contamination Needs (e.g., RL-SS25: Improved, Cost-Effective Methods for Subsurface Access to Support Characterization and Remediation).

This need focuses on the extension of our current knowledge of groundwater characteristics to support side-wide assessments. The structure and development of the regional groundwater plumes is critical to estimating inventory of contaminants in groundwater for site-wide assessments. This plume structure also provides information about controlling hydrogeology and is critical to calibrating and documenting the quality/performance of numerical models. In addition, hydrogeological characterization at multiple scales is needed to understand and predict the flows and transport at Hanford. As recommended by the peer review panel for the Hanford site-wide groundwater model in a recent review, the first step in developing this knowledge is evaluating the sources of uncertainty in the model. This will provide direction to areas where the characterization can have the greatest impact in reducing uncertainty.

The proposed need emphasizes the need for understanding the vertical penetration of contaminant plumes, both near sources and in regional plumes as contaminants travel toward the Columbia River. Developing a technically based understanding of this 3D behavior is important at several scales and is needed to reduce the uncertainty and improve the SAC at Hanford. Until recently, most site modeling and characterization of the groundwater has been performed in two dimensions with emphasis on the upper portion of the water table. Contaminants penetrating below this interval as a result of regional infiltration, geological features, or waste characteristics have not been fully addressed.

Near a waste disposal source, the vertical concentration profile and contaminant penetration are diagnostic of the release (volume, contaminant concentrations, and waste properties). Regionally, infiltration and boundary conditions result in plume trajectories that dip downward near the source, and then upward near the Columbia River. In both of these cases, the penetration and 3D plume geometry is strongly dependent on geological controls. Understanding this behavior will improve interpretation of data and will improve the robustness of models. This is especially important as predictions are extended to future conditions that differ significantly from the present day – i.e., what happens to the plumes when future groundwater levels decline and the water table is in the Ringold instead of the Hanford Formation?

This need targets technologies and approaches to fill this data gap in creative and cost effective ways and in a manner that is compatible with Hanford requirements and stakeholder values. Specific issues that need to be addressed to resolve this technical gap include the following:

- Information is needed to understand how to incorporate the 3D properties of contaminant plumes and regional-scale data into predictions of plume fate and transport. To provide input to fate transport models, techniques are needed to obtain representative data for the 3D distribution and chemistry of groundwater contaminant plumes and depth discrete and regional-scale information on aquifer hydrogeological properties. Means to assess the representativeness and quality of these sample/data collection methods are also needed.

- As part of the analysis of fate and transport for contaminants, information is needed to understand the relationship between the migration pattern of high mobility contaminants (e.g., ^{3}H, ^{99}Tc, and nitrate) and the migration pattern of moderate to low mobility (e.g., ^{129}I, ^{90}Sr, ^{127}Cs, and ^{60}Co) contaminants.

- An improved understanding of groundwater conditions such as high water levels to the east of the Columbia River is needed to describe and predict the subsurface distribution of contaminants. High water levels in east of the river will deflect contaminant plumes and alter the outcrop location – moving it upstream and toward the Hanford bank. Understanding this large scale, 3D concept will improve the technical basis for river impact assessment.

- Information is needed to determine which scales of physical/hydrological heterogeneity definition are needed to effectively predict contaminant fate and transport for both site-specific and site-wide assessments. Additionally, information is needed to understand how to relate hydraulic measurements acquired with different support scales or different volumes of investigation.

- An approach for defining and accounting for uncertainty of 3D contaminant distribution is needed for conceptual and numerical modeling of regional and site-specific plume structure.

- Information is needed on behavior of DNAPL and LNAPL wastes at Hanford. These wastes, such as dense CCl_4 and co-contaminants dissolved in the CCl_4, follow different migration paths than the dissolved contaminants in the groundwater.

Improved access to the subsurface that reduces cost and increases data density and improved methods for sampling groundwater are needed. Specifically, drilling costs with existing technology reduce the number of wells that can be drilled for characterization. New methods are needed for discrete-depth sampling of groundwater from both existing wells and during installation of new wells (Technology Need RL-SS25).

Schedule Requirements:

Earliest Date Required: 8/1/99

Latest Date Required: 9/30/05

The Integration Project S&T roadmap (DOE/RL-98-48, 2000) indicates the information that is required over the next 6 years to meet the objectives of the Integration Project. Information associated with delineating groundwater plumes is needed in the FY 2000 to FY 2004 timeframe to meet these objectives.

***Problem Description*:** This need falls under the Groundwater Technical Element within the S&T Endeavor. The Groundwater Technical Element is intended to address and resolve scientific issues related to understanding the role of groundwater in the overall migration of contaminants from the Hanford Site. The objective of the Groundwater Technical Element is to enhance protection of the Columbia River and its environs by 1) determining the existing distributions of contaminants with particular emphasis on 3D distribution especially at the interfaces with the vadose zone and the river and 2) enhancing the understanding of geological, chemical, geochemical, and hydrologic controls for future movement of contaminants. Detection of contaminants in groundwater monitoring wells underlying tanks, cribs, landfills, and other sources has often been the first indication of releases and migration. Understanding the flux and dynamics of vadose-capillary fringe-groundwater contaminant transfer and plume migration in three dimensions is critical to reconstructing vadose zone transport. On a larger scale, transport processes in groundwater control migration to extraction wells or surface water bodies (e.g., the Columbia River), define future risk scenarios, and affect the potential for optimized cleanup. An implicit goal of this research is to provide sufficient knowledge and data and identify existing and new S&T for input to DOE's decision-making process for Hanford cleanup.

This technical element provides the information, analytic capabilities, and understanding required for improving the technical basis for assessments of Hanford Site impacts to groundwater resources and the Columbia River. Groundwater represents an important portion of the potential exposure path and is the link between the source/vadose system and receptors at a well or the river. The technical scope of the groundwater element complements that of the vadose zone element by extending the characterization work into the saturated sediments under the Hanford Site. The saturated zone includes the capillary fringe, the unconfined aquifer, aquitards, and uppermost confined aquifers. The technical scope of the groundwater element also compliments that of the river element by providing input to contaminant flux to the river and other interactions between the groundwater and Columbia River. Major topics include (1) the distribution of contamination within the saturated sediments; (2) the hydrology, geology, geochemistry, and microbiology of the saturated zone; (3) groundwater flow and transport of contamination; and (4) numerical models that depict the movement of water and contaminants.

Benefit to the Project Baseline of Filling Need: The information generated to address this need will provide high quality estimates of contaminant position and behavior. Precise understanding the location of contaminant plumes is the most important basis for efficient and optimized remedial actions. The activity that this need supports will be used to support development of the SAC as part of the GW/VZ Integration Project. Successful completion of these activities is required to meet the objectives of the Integration Project and the related elements of the Paths to Closure.

***Functional Performance Requirements*:** The techniques applied or information that is obtained must delineate contamination distribution such that the information can be applied toward the conceptual models, fate and transport numerical models, and system assessment capabilities that are being developed as part of the Integration Project. The information must provide a better understanding of current conditions, and the ability to assess potential future conditions for near- and long-term scenarios.

Work Breakdown Structure (WBS) No. : 1.4.03.4.4 ***TIP No.:***

Relevant PBS Milestone: PBS-MC-042

***Justification For Need*:**

Technical: The structure of the regional plume for highly and moderately mobile contaminants is not fully defined and, thus, there is a limited scientific basis for collecting and representing geologic and hydrologic data over a variety of scales. The structure and development of the regional groundwater plumes is critical to estimating inventory of contaminants in groundwater for site-wide assessments and providing critical data to support site-wide groundwater modeling and its integration into the SAC being developed as part of the GW/VZ Integration Project. This plume structure also provides information about controlling hydrogeology and is critical to calibrating and documenting the quality/performance of numerical models. In addition, hydrogeological characterization at multiple scales is needed to understand and predict flow and contaminant transport at Hanford.

Regulatory: Information obtained by addressing this need will provide an improved technical basis for making site regulatory decisions and therefore reduce the uncertainty associated with the basis for these decisions.

Environmental Safety & Health: This need addresses broad sitewide technical issues and, as such, crosscuts multiple applications that each may have specific environmental safety and health issues.

Potential Life-Cycle Cost Savings of Need (in $000s) and Cost Savings Explanation: The estimated life-cycle cost savings associated with filling this need is $200M. This estimate is based on an assumed savings of 5% of the total Hanford remediation life-cycle cost of >$5B. Estimated savings are due to information and data gained by filling this need that supports decisions for cost effective remediation and long-term stewardship.

Cultural/Stakeholder Concerns: This technology need supports the resolution of cultural and stakeholder concerns as expressed by the CRCIA Team in “Columbia River Comprehensive Impact Assessment, Part II: Requirements for a Columbia River Comprehensive Impact Assessment” (DOE 1998).

Other: None.

Current Baseline Technology: N/A

End-User: Richland Environmental Restoration Project

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DOE End-User/Representative Point-of-Contact: John G. Morse, DOE-RL, (509) 376-0057

Reference:

United States Department of Energy. 1998. Columbia River Comprehensive Impact Assessment, Part II; Requirements for a Columbia River Comprehensive Impact Assessment. DOE/RL-96-16. United States Department of Energy, Richland, Washington.

United States Department of Energy. 2000. Groundwater/Vadose Zone Integration Project Science and Technology Summary Description. DOE/RL-98-48, Vol. III, Rev. 1, U.S. Department of Energy, Richland, Washington.